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Digital Heating Plate

Abstract

The heating surface of the digital heating plate is divided into small segments (S1, S2 ... S4), each segment having a heating source (H) and a heat detector (W). Each segment can thus be adjusted to any target temperature independently of the other segments so as to obtain a desired temperature sequence on the heating surface.

Introduction

Devices are needed for thermal testing in chemothermal reactions. The aim is to produce any temperature distribution as precisely as possible on any surface.

Prior Art

According to the prior art, there are devices with heating blocks that have, in principle, the following structure (Fig. 1):

The rectangular heating block (A) has two heating sources (B1, B2) and two heat detectors (C1, C2) as sensors at the two outer ends of the blocks. The heating sources generate two different temperatures to achieve the temperature sequence desired over the length of the block.

A linear temperature sequence according to the relation $\delta = al + b$ has hitherto been targeted, in which

- a = change constant
- l = longitudinal extension of the heating block
- b = lowest value of the temperature sequence, which has to be at least slightly higher than the ambient temperature.

In the block principle, the temperature distribution between the two heating sources B1 and B2 depends solely on the thermal conduction property of the selected material. It impedes the desired temperature distribution also if control points (C3, C4) are additionally provided in the block area between the heating sources (B1, B2). Even if additional heating sources (B3, B4) are incorporated in the block area, the result is unsatisfactory.

The heat distribution resulting from the block and the material also requires a considerable amount of time, on average 2 hours for, e.g., $\Delta\delta = 150°C$.

Additional disadvantages arise due to this principle:

- There is a considerable deviation from the target value, which is insufficient for many applications, for example 30 %.
- The reproducibility δ (l, t) is also insufficient for most applications.
- The structure described to date does not prevent undesired heat (in accordance with the laws of physics) flowing from hotter to colder points, with the consequence that distribution deviates even more.
- Owing to this structure, the time required to achieve a target distribution cannot be influenced at all and varies with the ambient conditions; every scientific examination in chemothermal reactions therefore empirically has a high element of uncertainty and time requirement.
- The temperature constant required in the transverse direction is insufficient in the block principle; it has been attempted to improve the longitudinal behaviour with regard to fluctuations by way of water-cooling, however the transverse behaviour of the temperature sequence deteriorated further owing thereto.

<u>Digital Heating Plate</u>

A digital heating plate that better takes into account the requirements is proposed herein (Fig. 2).

Instead of a block, the heating surface is divided into segments (S1, S2 ... Sn) that are as small as possible. Each individual segment (Fig. 3) has a heating source (H) and a heat detector (W) as a sensor, which are disposed in a body (M). The shape of a segment can be selected such that it satisfies the geometric demands on any heating surface. Fig. 2 shows an example arrangement of these segments to form a heating surface that is, for example, rectangular.

Owing to its structure, each segment can assume a defined target temperature that is independent of other segments. Since the flow of heat from a warmer to a colder segment has to be prevented, a thermal insulating material (I) is disposed between the segments (Fig. 3a). A thermoconductive material (L) is incorporated in this insulating material (I) such that inevitably penetrated heat can be dissipated into the environment.

The digital heating plate consists of a sufficiently large number of segments of the described type. Temperature sequences having any curve shape can therefore be realised on this digital heating plate.

A special material (G) on the heating surface has two purposes:

1. to considerably reduce fluctuations over time in the actual temperature of each individual segment (Fig. 4)

2. to exert an integrating effect over several segments (Fig. 5).

All segments can be controlled centrally. This is possible because each segment forms a completely self-contained unit. A temperature error can be corrected immediately because the heating power of each segment is a multiple of the nominal power.

The connection between the heating element and the segment or body (M) is designed such that there is as little loss as possible. The same applies to the connection to the sensor.

The target/actual deviation of each segment ($\pm$ 0.3°C) applies to the entire surface of the digital heating plate. The reproducibility of the temperature is accordingly high.

The formation of segments in the digital heating plate has a further advantage: the time required to achieve the target value of each segment can be reduced, for example, to three minutes at $\Delta\delta = 150$°C – this value also applies here to the entire heating surface.

A further advantage of forming segments in the digital heating plate is that each individual segment can be controlled very quickly owing to its accordingly much lower heat capacity. As a result hereof, water-cooling is rendered completely unnecessary.

Patent Claims

1. Digital heating plate, characterised in that a number of segments (S1 to Sn) form this heating plate and that any predeterminable temperature sequences can be realised in terms of place and time δ (l, t) with a resolution proportional to the number of segments (S1 to Sn), it also being possible for δ to be lower than the ambient temperature.

2. Digital heating plate according to claim 1, characterised in that segments S1 to Sn form a flat surface.

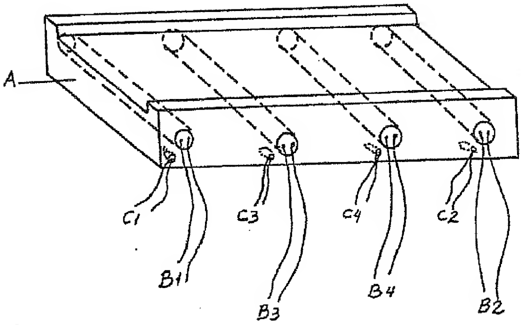
3. Digital heating plate according to claims 1 and 2, characterised in that a heat insulator (I) according to Fig. 3a is disposed between the segments S1 to Sn to prevent the flow of heat from one segment to another.

4. Digital heating plate according to claims 1, 2 and 3, characterised in that a thermoconductive material (L) is disposed, perhaps alone or with gap formation, in the heat insulator (I) to dissipate inevitably penetrated heat into the environment.

5. Digital heating plate according to claims 1 to 4, characterised in that a material (G) is disposed over the surface formed by the segments S1 to Sn so as to
   a) considerably reduce fluctuations over time in the actual temperature of each individual segment (Fig. 4) and
   b) exert an integrating effect over a plurality of segments (Fig. 5).

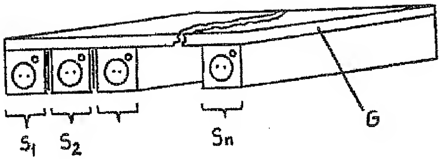
6. Digital heating plate according to claims 1 to 5, however deviating from claim 2, characterised in that any bent surfaces, for example bowls, as well as closed surfaces, for example cylinders, can be formed from the individual segments S1 to Sn.

Fig. 1



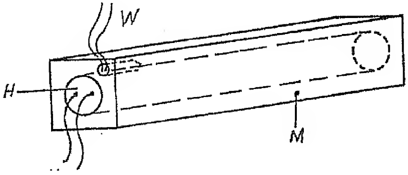
A: Heating block
B1, B2, B3, B4 = Heating source
C1, C2, C3, C4 = Heat detector

Fig. 2



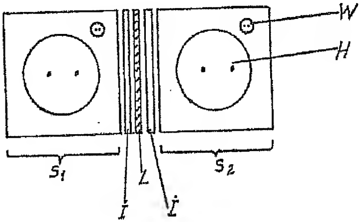
S1 … Sn: Segments
G: Special material

Fig. 3



H: Heating source
W: Sensor
M: Body

Fig. 3a



I: Insulating material
L: Conductive material

Fig. 4

Temperature fluctuations over time individual segments

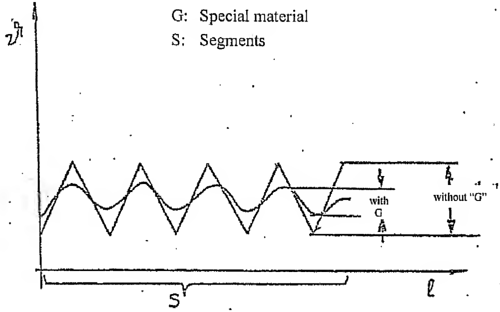


Fig. 5

Temperature fluctuations over time over several segments